

OUTREACH AND PARTNERING

With outstanding scientific and technical capabilities and an important national security mission, Lawrence Livermore National Laboratory is a national resource. The Laboratory's continuing success depends on engaging sponsors and actively participating in the broad scientific community to understand emerging national needs and technical opportunities. Success in the Laboratory's research programs depends on strong ties to research universities and partnerships with U.S. industry.

The Laboratory's closest academic ties are with the campuses of the University of California (UC). In addition to more than 500 ongoing collaborations between Laboratory scientists and UC colleagues, joint research centers foster interdisciplinary collaborations. These academic partnerships strengthen research programs at Livermore and the campuses. University ties also serve as a valuable pipeline for recruiting new talent to the Laboratory. Partnerships with U.S. industry bring valuable research tools to Livermore programs—from the world's fastest computers to the world's largest laser. Industrial partnerships also facilitate the transfer of the Laboratory's technological advances to the marketplace.

Lawrence Livermore is an important regional resource, too, contributing to the intellectual vitality of the San Francisco Bay Area and California's Central Valley. The Laboratory provides Californians with information and expertise on issues ranging from homeland security to groundwater management. Partnerships also abound through educational, business development, and diversity outreach programs. The Laboratory supports a wealth of science education programs and works with local universities and colleges to provide high-technology workforce training.

Being a good neighbor is important to the Laboratory and its employees. Lawrence Livermore's 8,000-plus staff members and their families contribute generously to the well-being of neighboring communities through charitable contributions and volunteer work.



Science and Technology for California

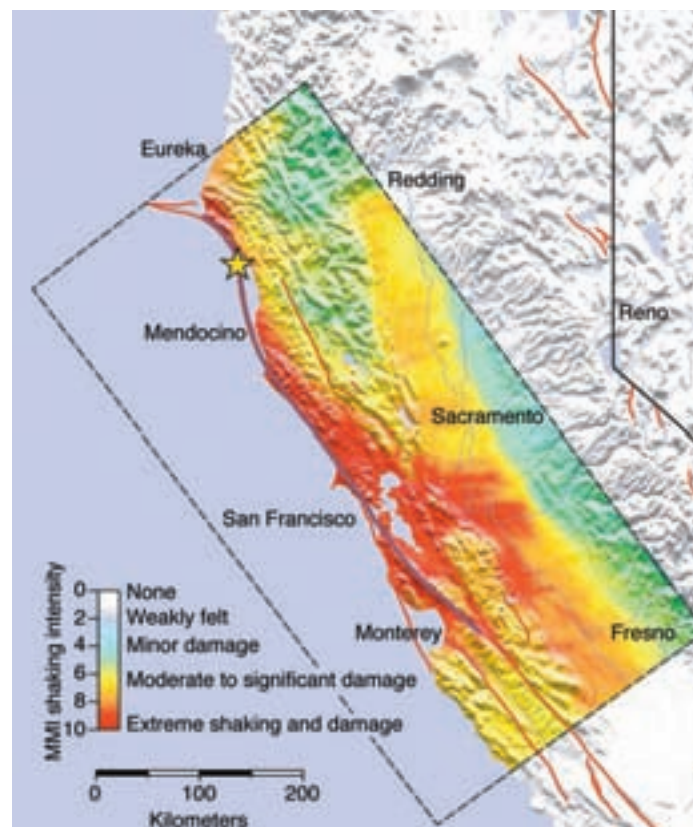
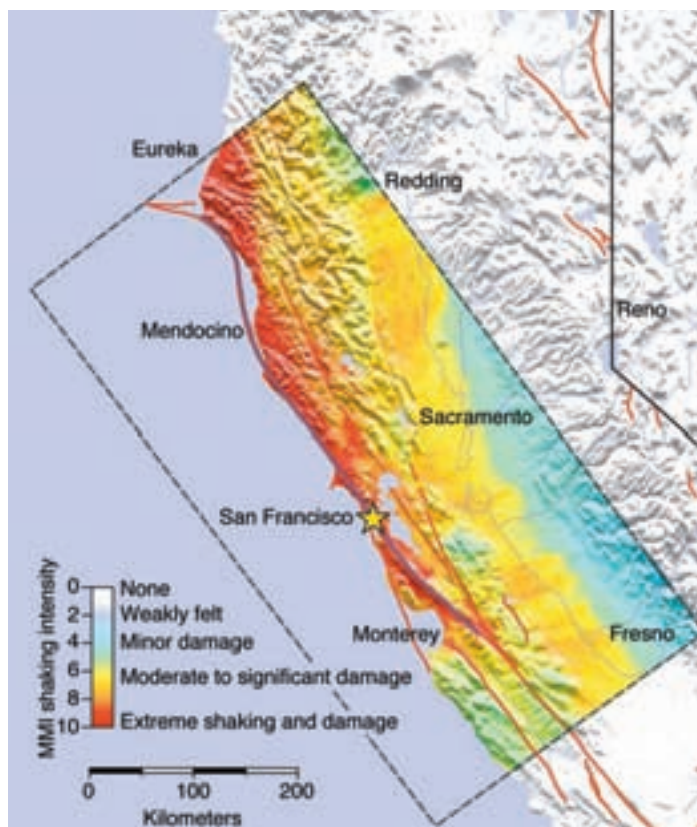
The Laboratory marked the centennial of the 1906 San Francisco earthquake with presentations in April by two invited experts, who discussed historic and potential future earthquakes in the Bay Area. During the day of activities, members of the media were invited to a session where Livermore researchers unveiled detailed simulated re-creations of the 1906 earthquake as well as simulations of temblors along other local faults that could have devastating effects on the Bay Area, Central Valley, and Delta regions of California.

The simulations, performed with the U.S. Geological Survey, made use of high-performance computers, three-dimensional models of geology, and a seismic velocity model to assess damage. The earthquake simulations along the Bay Area's major faults showed the potential for severe damage to major transportation corridors, power lines, and water pipelines. Impacts in the Delta region include possible damage to levees, buildings, and bridges.

The Laboratory is also working with the State Water Resource Control Board in the Groundwater Ambient Monitoring Assessment (GAMA) project. Livermore is applying its state-of-the-art facilities

for age-dating tritium (helium-3) and methods for low-level detection of tracers to pinpoint the sources and determine the migration of groundwater contaminants. The GAMA project focuses on 116 priority groundwater basins that account for 90 percent of the state's groundwater use. Laboratory scientists are analyzing and interpreting the results from samples taken from selected municipal water supply wells and providing the results to the State Water Resource Control Board and the U.S. Geological Survey.

In 2006, the Laboratory completed a study that identified the sources of



A simulation of the 1906 San Francisco earthquake (left) shows the perceived shaking experienced from Eureka to Fresno, with the historical epicenter along the San Andreas Fault, denoted by the star. A second simulation shows a hypothetical earthquake of the same magnitude with an epicenter much farther north and rupturing to the south. Although the epicenter is farther away, the shaking experienced in the San Francisco and Central Valley areas is much greater than during the 1906 quake. These simulations used the Laboratory's Thunder and MCR supercomputers and Japan's Earth Simulator. The simulations are displayed at <http://earthquake.usgs.gov/regional/nca/1906/simulations/>.

nitrates in the groundwater in a portion of Alameda and Contra Costa counties. The region has a long history of agricultural activity and is increasingly urbanized. Nitrate contamination poses a threat to using groundwater to meet the growing demand for drinking water. Nitrates can come from application of synthetic fertilizer, confined animal operations, septic system discharge, or oxidation of nitrogen in the soil. In this case, naturally occurring nitrogen in the soil is the most likely source of the high levels of nitrate in the groundwater.

Other applications of the Laboratory's science and technology that are important to the State of California include regional climate modeling (see p. 26) and many projects to strengthen homeland security. Laboratory researchers are also helping to control animal diseases that could be a threat to agriculture (see p. 20) and developing emergency-response capabilities and procedures in projects with the Port of Oakland and San Francisco International Airport.

Educational Outreach

The Laboratory's science education programs and activities reach students and teachers in local communities, the San Francisco Bay Area, and the Central Valley. More than 12,000 students in kindergarten through junior college as well as hundreds of educators participate in a range of activities.

Programs for students are many and diverse. For example, "Science on Saturday" is a five-week series of free lectures and demonstrations by top Livermore researchers on topics at the forefront of science and technology. Targeted at middle- and high-school students, the series is so popular that it was expanded in 2006 to better

accommodate the large attendance of the previous year. The lectures were recorded for broadcast by the University of California Television Network, and the series was repeated for students in the Central Valley.

Now in its third year, "Got Science?" is a popular one-day family-oriented event held at the Robert Livermore Community Center. More than 3,000 visitors filled the center for hands-on science and engineering activities, displays, and fun. The event offered approximately 30 exhibits staffed by Laboratory volunteers.

Livermore's Edward Teller Education Center (ETEC) is home for a variety of professional development programs for kindergarten through junior college educators. Sponsored by the Laboratory, the UC Office of the President, UC Davis, and UC Merced, the center aims to improve the quality of science

instruction and technology applications in the classroom. ETEC hosted computer technology workshops as well as the seventh annual Edward Teller Science & Technology Education Symposium, a two-day event held in September. More than 200 California teachers received the latest topical science information as well as lessons and activities for use in the classroom.

Another outstanding ETEC activity is the Teacher Research Academy in biotechnology, biophotonics, and fusion/astrophysics. The academy is co-sponsored by UC Davis and held as 12 regional workshops. It introduces teachers to breakthrough science and concludes with a six- to eight-week internship in a Livermore research laboratory. A unique opportunity for educators, the Teacher Research Academy was featured in the American Physical Society summer *Newsletter*.



At "Got Science?," Mike Revelli (left) and Don Nelson show local children how magnets work.

Tri-Valley Science and Engineering Fair

The Laboratory is the organizing sponsor of the Tri-Valley Science and Engineering Fair, which was in its tenth year in 2006. The fair stimulates interest in science and technology among middle school and high school students from the Dublin, Livermore, Pleasanton, San Ramon, and Sunol school districts. The Tri-Valley Fair is affiliated with the Intel International Science and Engineering Fair (Intel ISEF), the world's largest pre-college celebration of science. A middle-school winner at the 2006 fair took first place at the California State Science Fair, and the high-school winners took awards at Intel ISEF.



A middle school student demonstrates "Effect of Mass and Length on Time Period of Pendulum" in the Tri-Valley Science and Engineering Fair's junior category.

Laboratory firefighters Aaron Horn (left) and Mike Hamilton gathered toys, stuffed animals, and games for the annual Toys for Tots drive.

A Good Neighbor

Laboratory employees actively participate in educational outreach programs as well as various charitable and economic development organizations. More than 500 staff members each year volunteer their time to serve as science lecturers, mentors, science fair judges, and presenters or instructors in workshops and classrooms. The Laboratory's Public Affairs Office provides a listing at its website (www.llnl.pao) of community outreach activities, public events, and available tours as well as on-line copies of its *Community Newsletter*.

The Laboratory's Helping Others More Effectively (HOME) campaign raised nearly \$1.5 million for Bay Area and San Joaquin Valley charitable organizations in 2006. Livermore employees marked their eighth straight year of contributions totaling more than \$1 million. The Laboratory is the largest single workplace supporter of the Tri-Valley Community Fund, which is dedicated to raising and distributing

local charitable contributions to human service, educational, cultural, and recreational organizations.

Employees also generously support programs such as Toys for Tots and the Laboratory's Brighter Holidays for local families in need during the holiday season. Each spring, Livermore employees buy thousands of daffodils as part of the American Cancer Society's Daffodil Days®. Lawrence Livermore topped the list of fundraisers for Daffodil Days in 2006 for the San Francisco Bay Area and for all of northern California.

Research Collaborations with the University of California

Collaborations between the Laboratory and UC campuses strengthen research programs at Livermore and provide the campuses with access to Livermore's multidisciplinary capabilities and special research facilities. More than one-quarter of the roughly 1,000 peer-reviewed journal articles produced each year by



Laboratory scientists are coauthored by colleagues at UC campuses. Larger-scale collaborations take place through partnerships in research institutes on campuses and at the Livermore site.

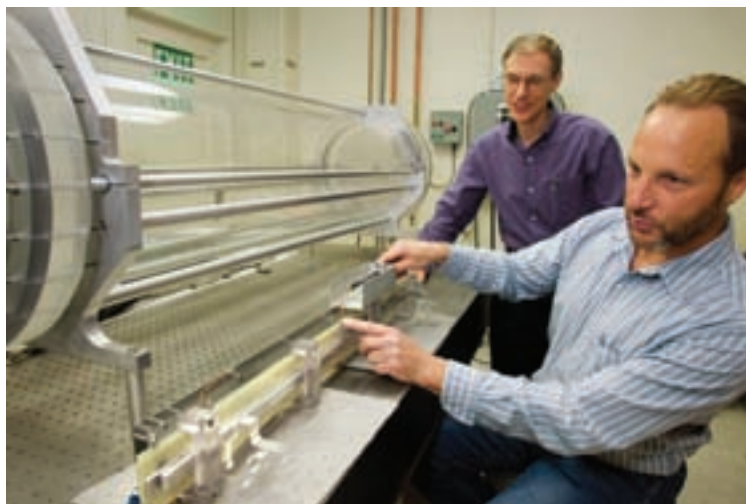
One of the Laboratory's many strong ties with UC is the UC Davis Cancer Center, a National Cancer Institute-designated center. The center's program includes about 180 scientists at work on more than 300 cancer projects on three campuses, including the Laboratory. In the partnership, physicians and scientists work to turn technology developed for national security applications into new cancer therapies, detection methods, and prevention strategies. Laboratory contributions to the fight against cancer include optical imaging techniques to differentiate malignant cells from healthy ones, the use of accelerator mass spectrometry for medical applications (see p. 29), and development of a new

device to deliver proton radiography to cancer patients.

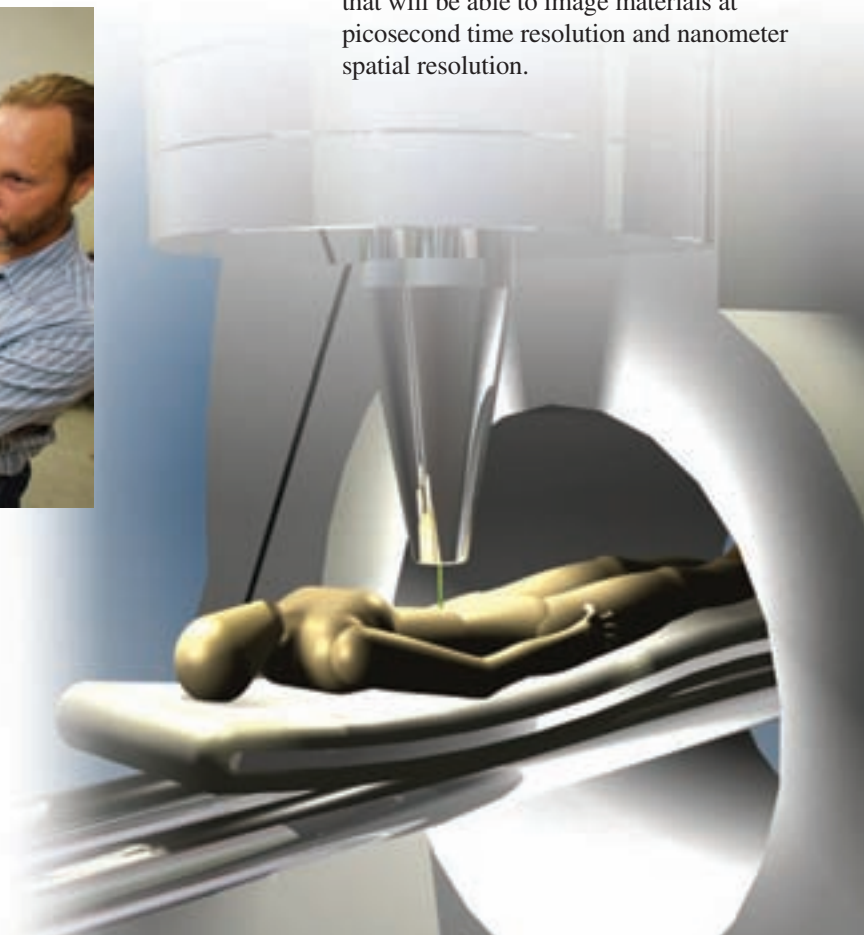
With UC support and reinvested contract management fees, scientists from Livermore and UC San Diego are collaborating on global climate change and cosmology projects and supporting computational tools. The focus of the climate change research is the regional impact of change on water supplies—with a particular interest in the western United States. Another team is performing high-resolution simulations of the evolution of galaxy clusters in the early universe. These results will be combined with data to come from the Large Synoptic Survey Telescope (another project with major Laboratory participation) to map the distribution of matter in the universe. In both areas, vastly improved scientific data management technologies are needed to organize, analyze, and manipulate large sets of

observational and simulation data, from hundreds of terabytes to petabytes. Researchers in many fields will benefit from the development of the new tools.

The Laboratory is also a key participant in the Institute for Material Dynamics at Extreme Conditions (IMDEC), a newly formed UC Multicampus Research Program that is based at UC Berkeley. IMDEC will bring campus and national laboratory scientists together to examine fundamental issues in the ultrafast dynamics of materials at extreme conditions (see p. 10). Tools used by IMDEC researchers will include Livermore's Jupiter Laser Facility. One proposed major project is to build a laser and target chamber for the Linac Coherent Light Source at the Stanford Linear Accelerator Center for ultrafast imaging. Another proposal is to build a next-generation dynamic transmission electron microscope (DTEM)—an improvement upon the Laboratory's existing DTEM that will be able to image materials at picosecond time resolution and nanometer spatial resolution.



Mark Rhodes (right, above) and George Caporaso adjust a prototype Blumlein transmission-line generator, which will generate power inside the compact proton accelerator for cancer treatment.



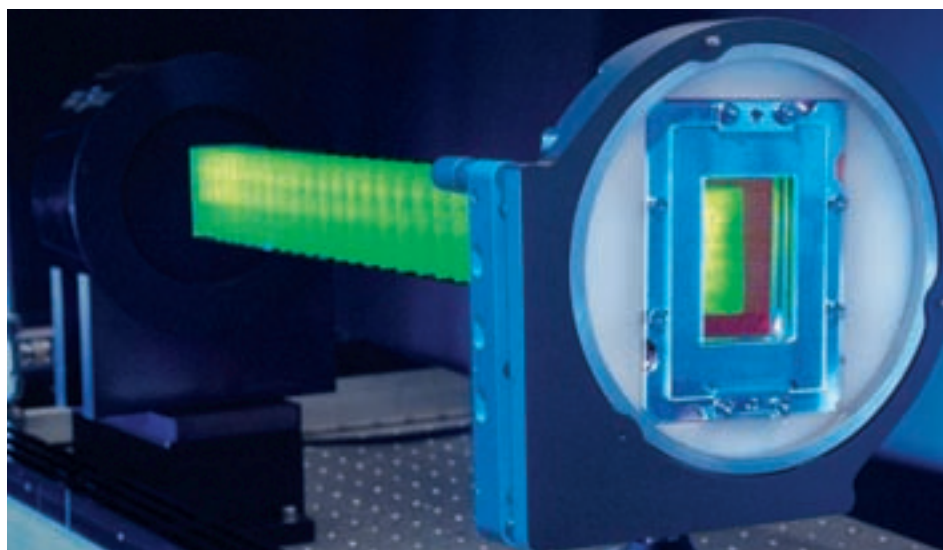
Laboratory Technologies Reap Awards

In 2006, Livermore scientists and engineers—and their research partners—earned seven R&D 100 awards, more than any other institution. Each year, *R&D Magazine* presents awards to the 100 top technological advances of significant potential benefit to society.

Since 1978, Laboratory researchers have won 113 R&D 100 awards, and many of these inventions were developed in partnerships or have been transferred to U.S. industry for commercial development. Laboratory-developed technologies contribute to U.S. economic competitiveness in world markets. The transfer of technology to industry also promotes economic

development both locally and throughout the United States.

This year's R&D 100 award winners include three systems applicable to homeland and national security: the Sonoma Persistent Surveillance System (see p. 17), the Easy Livermore Inspection Test for Explosives (E.L.I.T.E.) pocket-sized explosives detector (see p. 21), and the UltraSpec ultra-high-resolution spectrometer that can be configured to detect either gamma rays or neutrons. Two additional R&D 100 awards were granted for computer software: Babel, which allows software modules written in different programming languages to seamlessly pass scientific data to each other, and Sapphire, a sophisticated tool for mining scientific information from terabytes of data.



The award-winning single yttrium-calcium-oxyborate crystal in the center of the holder shifts incoming invisible infrared light on the right to green light on the left, a task that formerly required four crystals.

A technique called Externally Dispersed Interferometry, which will assist in the search for distant planets, also won an R&D 100 award. The seventh winner is the yttrium-calcium-oxyborate (YCOB) crystal plate for efficient frequency doubling of laser light. The advantages of YCOB crystals over other methods of wavelength conversion will greatly boost laser research and the development of future high-power systems.